

RELATIONSHIP BETWEEN SOLAR ACTIVITIES AND THUNDERSTORM ACTIVITIES IN THE BEIJING AREA AND THE NORTHEAST REGION OF CHINA

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ABSTRACT

An analysis of the relationship between the IMF section boundary crossing, solar flares, the sunspot eleven-year cycle variation and the thunderstorm index is given, using the superposition epoch method, for data from more than 13,000 thunderstorms from 10 meteorological stations in the Beijing area and the Northeast region during 1957 to 1978. The results show that for some years a correlation exists between the thunderstorm index and the positive IMF section boundary crossing. The thunderstorm index increases obviously within three days near the crossing and on the seventh day after the crossing. The influence of the crossing on thunderstorms is stronger in the first half year than the latter half year. For different classes of solar flares, the influences are not equally obvious. The solar flares which appeared on the west side, especially in the western region (from 0° to 30°) have the most obvious influence. There is no discernible correlation between the thunderstorm index and the sunspot eleven-year cycle.

INTRODUCTION

As early as AD 187 there was a written record of the correlation between solar activities and meteorology in an ancient Chinese book: "there is a black color as large as a melon within the Sun. When the Sun becomes black, the water on the ground will be flooding." It indicates a correlation between the peak of the sunspot and floods. Recently there is a number of statistical data analyses in China on floods and droughts, precipitation, characteristics of rains, water flow of rivers and water levels of rivers and lakes and so on, which reveal certain correlations with solar activities. As usually realized, annual precipitation is, to a certain extent, linked with thunderstorm activities. Thunderstorms are phenomena of atmospheric electricity. In order to understand the physical mechanism of the correlation between solar activities and meteorological phenomena such as precipitation, several ways have been proposed through which the effects of solar activities can transport into the lower atmosphere and give some impact upon meteorological phenomena. Atmospheric electricity is one of the most possible ways. The possible picture seems like this. Solar activities may influence the environment of atmospheric electricity. Atmospheric electrical properties may influence the formation of thunderstorms, and then influence the annual precipitation and other related meteorological phenomena.

In China we have systematic collections of thunderstorm data for the whole country covering more than a million square km over the last 20 years. These data are very unique for analyzing the correlation with solar activities. The work shown here was done in 1986, based on data of 10 basic meteorological stations in Beijing and the Northeast regions. These areas are not the most frequent thunderstorm regions, but there were still about 13,000 thunderstorms during the 19 years from 1957 to 1978.

CALCULATION

The superposition epoch analysis is used to analyze the correlation between the Interplanetary Magnetic Field (IMF) section boundary crossing, solar flares and the index of thunderstorms. The definition of the index of thunderstorm τ is: $\tau = (f - \bar{f}) / s$, where f is the number of thunders per day; \bar{f} is the average value of f of the same epoch days included in the superposition analysis; s is the standard mean deviation of the fluctuation of f for each epoch day.

During the analysis, different classes of data were divided according to different situations, such as: for different years, i.e., the first half year (from April to June), the latter half year (from

July to October), and the whole year; for different solar activity levels, i.e., high activity years (57-59, 68-70), low activity years (63-65, 57-77), ascending years (65-67) and descending years (59-63, 70-75); for different polarities of the section boundary, i.e., positive boundary (the direction of IMF being away from the Sun turns toward the Sun), and negative boundary (IMF toward the Sun turns away from the Sun); for different locations of solar flares on the solar disk, i.e., six regions as E1 (0° - 30° east of the central meridian of the solar disk), E2 (30° - 60° east), E3 (60° - 90° east), W1 (0° - 30° west of the central meridian of the solar disk), W2 (30° - 60° west), and W3 (60° - 90° west); for different durations of the solar flares, i.e., shorter than 1.5 hours and longer than 1.5 hours; for different brightness of the solar flare, i.e., bright flare and non-bright flare, and so on.

RESULTS

(A) IMF Section Boundary Crossing

For whole year data, about one third of the thunderstorm index shows a discernible correlation with the boundary crossing, being much more obvious for positive boundary than negative boundary.

Figure 1 shows some examples of the superposition epoch which shows the correlation between the index of thunderstorm frequency and the positive boundary crossing of interplanetary magnetic field sections. The upper two panels are Northeast data from 4 stations in 1968 and 1976. N is the number of total cases. Dotted lines are confidence level of 1%. Figure 2 is for negative boundary crossing. The lower two panels are the Northeast region. The upper three panels are the Beijing region.

(B) Solar Flares

Figure 3 shows an example of the superposition epoch curve of the thunderstorm index with respect to solar flares. The key days are solar flare burst days. For all cases of the east region solar flare, both the northeast region and the Beijing region the correlation exists only for a bright flare whose duration t is less than 1.5 hours and appears in the east region 2 of the solar disk. For the west region solar flare, region W1 is the most obvious region in which the solar flare will seemingly influence thunderstorm frequency.

CONCLUDING REMARKS

Having conducted all the superposition analyses for the different classes of data, we will summarize our impression about the correlation between thunderstorms and solar activity, including the IMF boundary crossing as follows:

1. The influence of magnetic boundary crossings on thunderstorm frequency is rather weak. Only a few years' data show an increase of thunderstorm frequency within 3 days or 7 days after the positive boundary crossing. Almost no influence after a negative crossing.
2. The influence of solar flares on thunderstorms is rather obvious. The thunderstorm frequency experiences a discernible enhancement after the flare burst, especially for the flare which appears in the west and especially in region W1 of the solar disk.
3. Statistics for the first half and the latter half year data show that the influence of the latter half year solar flare is stronger than the first half year flare.
4. The correlation between sunspot number and thunderstorm frequency is not discernible.
5. The results of the correlation statistics for different cases are different; for the Northeast and Beijing regions are also different. The results from our data are not identical with other authors. These facts show that the influence of solar activities on thunderstorms may be affected by local meteorological conditions.

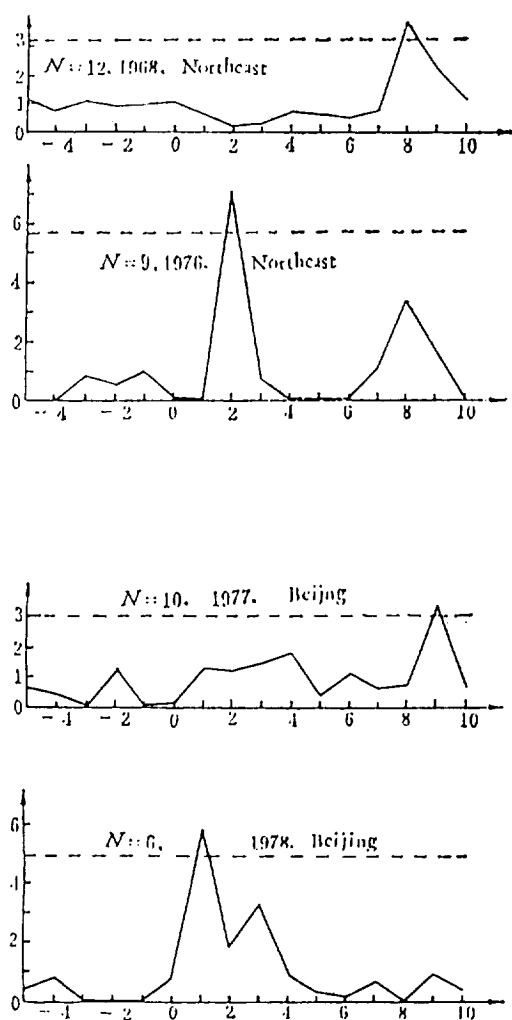


Figure 1. Superposition epoch analysis of thunderstorm index to positive IMF section boundary crossing.

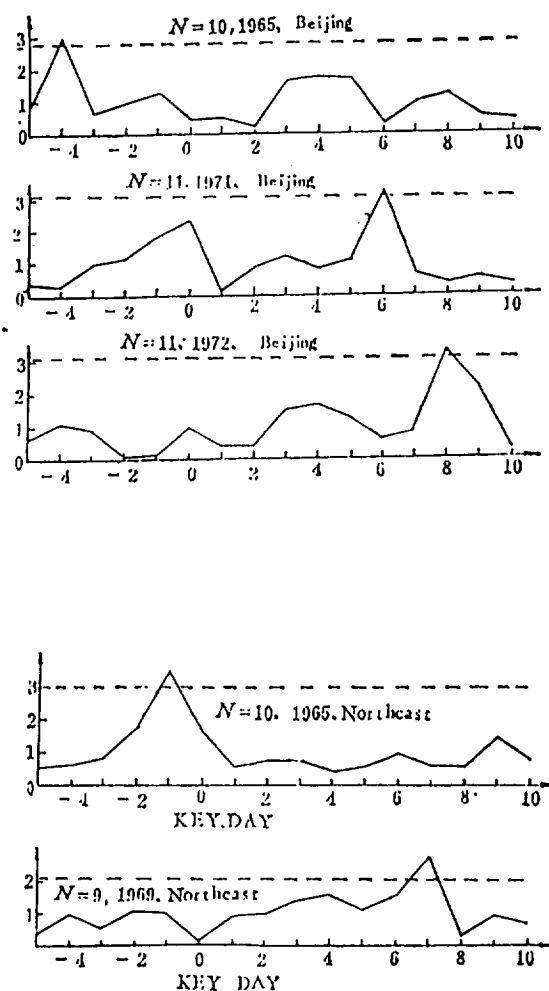


Figure 2. Superposition epoch analysis of thunderstorm index to negative IMF section boundary crossing.

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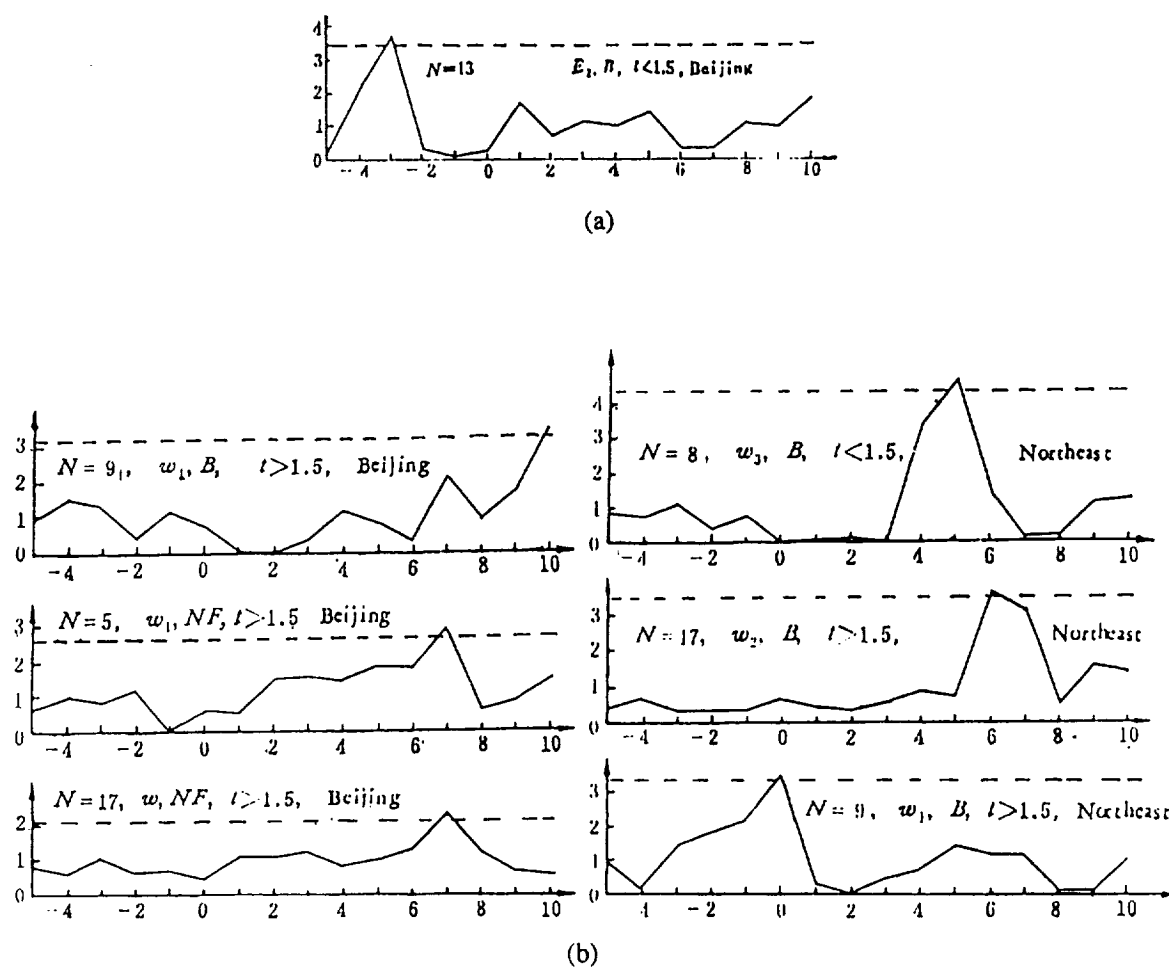


Figure 3. Superposition epoch curves of thunderstorm index to solar flare burst day. (a) appeared on the east side; (b) appeared on the west side.